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The Work of the College of Agriculture

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During the early years of this college, it was our practice to require the preparation of an annual report on the work of the Department of Agronomy, and two of these reports were published in early numbers of the Agriculturist and Forester. After the publication of these reports, the work of this department grew to such a scope that the publication of the reports with the available means became impossible; and after one more year, the point was reached where even the preparation of such reports with the available clerical help became altogether impracticable. The last such report which was prepared, but never published, was in part out of date before it was finally completed. It remains a matter of general interest that the work of this college, and particularly its practical and technical work, should be understood as widely as possible. For this purpose, a report much more condensed than those previously prepared, which still will give an adequate idea of the scope of the work being done in the college, and of the subjects being investigated here, but without a detailed statement of results, except where these are especially important, must suffice. During the last session of the legislature, I was called upon to submit for the use of a committee of the Philippine Assembly a statement of this kind with the inclusion of a mass of specific recommendations. In the following pages, this report is published as a matter of general interest, with the omission of such discussions of administration and such specific recommendations as might not properly be published or at any rate would not be of public interest. In the compilation of this report, I was assisted by Professor Baker, particularly in the parts which relate to grains, legumes, orchard crops and Animal Husbandry.

The statement of work previously done in this college must be justified by the records, part of which have been published, and all of which are available to any person, and will be published as rapidly as possible. As regards the statements of work being done, statements of this kind are sometimes inflated, and are therefore open to suspicion. There are listed in this report 62 separate subjects of investigation for which it is claimed that the work has reached the point where definite results are assured. The date of this report as submitted was November 26, 1915, and everything in the report is to be understood as effective on that date. Of these studies, some, like the examination of coconut varieties, can only be completed after the lapse of a number of years. The average time necessary for the conclusion of these different investigations is probably somewhat more than two years. This statement goes to press April 11th. During less than five months, there have been finished, written up and prepared for publication, twelve of these investigations; that is to say, they are being finished at the present time as rapidly as is necessary to complete the number stated as under way within the time required for the completion of the average subject. While twelve have been completed in the past five months, more than twenty new projects have been taken up.

The instruction given here in Language and Mathematics has for the most part been purely general education, and could as well be given to these students in the high schools of the Islands. Since we give these subjects to our students to occupy a part of their time during the two years when the essential reason for their being here is the training in Botany, we take advantage of the opportunity to give in the Algebra and Geometry more problems relating to the profession of agriculture than are usually given in such courses; and taking advantage of the same opportunity, make a practice of requiring in the English classes the preparation of themes on agricultural subjects, and in the German classes require the students to make translations of papers of agricultural interest.

Botany

Botany is taught here as the essential scientific basis of plant industry. It is our idea that Agronomy is applied Botany, and that students must be well trained in the principles of plant structure and plant life, before they can be expected to apply these principles with intelligence in their more purely technical studies. For this reason, the great majority of our students are required to take one year of general Botany and one year of the physiology of plants, before they begin their work in Agronomy.

The instruction in this department includes the basic facts on which the possibility of practical application depends. This instruction is from the first day given with constant emphasis on the utility, in agriculture and forestry, of the facts which are taught. Plants of economic importance furnish the materials for the study of both structure and physiology, so that when students reach the study of our crops in Agronomy, they are ready for practical instruction and do not need preliminary explanations. For example, before our students reach classes in Agronomy, they have already studied the stem structure of maize and several others of our crops; the roots of the coconut and other crops; the leaves of abaca and other crops; the flowers of bananas and the majority of our important crops, the response of garden crops to the application of stable manure and other fertilizers; the effect

of shade on the rate of growth and on other physiological processes of coffee, maize, etc.; the rate at which water, carrying the mineral food, is taken up by the roots of various crops and evaporated from the leaves; the rate at which the food which plants take from the air is utilized by several crops; and the dependence of these processes upon light, heat and water. It is only because our students entering the Agronomy classes are already supplied with this mass of information, and trained in the methods of securing such information with accuracy, that it is possible at all for our Department of Agronomy, during the years that our students are in its care, to cover the enormous field of Philippine plant industry with any satisfactory measure of completeness.

Aside from this general training for the purposes of our departments of Agronomy and Forestry, the Department of Botany, as a matter of administrative convenience, takes up in connection with its class work various particular problems which would fall to the Department of Agronomy, if Botany did not handle them. As an illustration, our class in Botany II is investigating the breeding of papaya (—1*—) and undertaking to establish a method by which it shall be possible to plant a field with papaya with the certainty that every plant set out will produce fruit, instead of having approximately half of them turn out to be pure male (sterile plants) as usually happens at present. To indicate the measure of provisional success which we have reached, I will state that I set out eighty plants last year in my own yard, and seventy-nine of them turned out to be fruit-bearing.

Until this year, all class work in vegetable gardening has been handled by the department of Botany, but since Mr. Cocannouer's arrival this has been turned over to the department of Agronomy. The department of Botany continues, however, to work with ten of the local garden crops in connection with its class work on fertilizers. The class work in Botany also includes an exceedingly careful study (-2-) of the relation of the rate of growth of plants to moisture and temperature, and in connection with this work, has already included more than one million determinations of rate of growth. In making these determinations, we have accumulated an amount of information which was never before at the disposition of any similar institution, with regard to the adaptability of various plants to different situations.

Because of inadequate personnel, the Department of Botany has been forced in the past to refuse to let many students conduct investigation in the department. One student, Mr. Espino, was allowed to do this last year, and made a study of the abaca plant, which showed among other things that the fiber from the different parts of the individual plant is very different in tensile strength and fineness, and indicated that such separation as would be practicable before the fiber is stripped would add very materially to the market value of the entire production of fiber from the plant. I do not believe that the general utilization of Mr. Espino's results would add less than 10% to the value of the abaca production of the Philippine Islands. This paper is ready for publication.

My advanced class in Plant Nutrition, Botany III, beside a general study of the subject more intensive than is a part of Botany II, has two very important practical special problems which occupy the most of the time of all of the eight students in the class. The first of these is (-3-) the relation of shading to the absorption of plant food from the soil.

* These numbers refer to investigations now under way at the college.

The subject of this series of experiments is tobacco. The finest wrapper leaf tobacco in the world, which brings by far the highest price paid for any tobacco, is everywhere raised under artificial shade. Natural shade, that is, shade furnished by other larger plants, would be cheaper; but the objection to this, even if the shade were equally uniform, is that the larger plants would take the food from the soil at the expense of the tobacco. Recently published experiments by the United States Bureau of Plant Industry seem to show that shaded tobacco will absorb relatively more food from the soil than would unshaded tobacco. If this conclusion is correct, it must follow that shaded tobacco can grow thriftily with less food in the soil than can tobacco in the open sunshine, and that, therefore, tobacco can be expected to grow well if shaded by other plants. Such practice would cheapen the production of wrapper leaf and make the cultivation of wrapper tobacco under natural shade the best practice. If we believed the Washington results, we would accordingly recommend the use of natural shade. The fact is that we do not believe the Washington results, because they are contradictory to certain fundamental principles of plant physiology. But these Washington results are published on such eminent authority that we feel obliged to test the question very thoroughly before we are at liberty to ignore them. It is our belief that tobacco grown under any shade will absorb much less food from the soil than would tobacco in the sun. If this is true, it follows that shaded tobacco should be planted on richer soil or else more heavily fertilized. In our experiments, we are making repeated tests of the amount of food which is taken from the soil by tobacco in the sun and in the shade. From these experiments, we can decide with confidence how much food and what food must be in the soil for tobacco grown under shade and for tobacco in full sunlight. We have already finished one series of these experiments, with the results which we anticipated,—that the Washington publication is peculiar. If the experiments now under way yield the same expected results, we will then be ready to publish a correction of the Washington statements, and to give definite advice as to the kind of shade necessary for the production of the best wrapper tobacco in the Philippines, and for the proper fertilization of such tobacco. Work of this kind demands the use of plants of absolutely uniform parentage; it is because the fine work already done in breeding tobacco by our Department of Agronomy furnishes us the necessary strains that we are able to carry on this work here with the same measure of thorough reliability which can be claimed for work by the United States Government.

The other practical problem of the Botany III class deals with (-4-) the nitrogenous food of rice. Experiments in Japan and Hawaii and preliminary experiments here all show that paddy rice requires nitrogenous food in the form of a salt of ammonia, whereas every other important cultivated crop hitherto well studied will thrive best if its nitrogen is furnished in the form of a nitrate. Nobody knows whether this is because the rice is a peculiar kind of plant, or because of the fact that rice is raised on wetter soil than any other crop. The production of upland rice is exceedingly important in the Philippines. It has been believed generally that, except on virgin land ("kaiñgins"), upland rice is less profitable than lowland rice. Local observations on our own ground several years ago showed that the culture of upland rice resulted in loss, which the growers failed to realize only

because they placed no value on their own labor. More recently, one of our graduates, Mr. José Zamora of Tarlac, has demonstrated beyond the possibility of doubt that by a particular system of culture which he has developed, it is possible to raise upland rice with hired labor and to realize a bigger profit on the investment than he is able to secure with lowland rice. The general use of the methods which Mr. Zamora has developed may make upland rice the most important single crop of the Philippine Islands. Under these conditions, the study of the kind of food required by upland rice becomes an exceedingly important one. The Botany III class is undertaking to decide whether upland rice is like lowland rice in demanding ammonia as the source of its principal food, or like other grains of dryer lands, such as wheat and maize, in preferring its nitrogen in the form of a nitrate.

A peculiarity of our course in Botany is the strong emphasis given to the study of the fungi. So far as I know, there is nowhere another institution where the first year's work in Botany includes as thorough a study of the fungi as it does here. This study is careful enough so that the students, on the one hand, know something about what fungi are useful as human food, and on the other hand, know enough about the fungi which are pests of our crops, so that when the crops are studied, they already know the nature of the organisms which cause the diseases of these crops.

The fungi as has already been noted are of economic importance in two diametrically opposed respects. A large number of the higher fungi are capable of furnishing delicious food of very high nutrient value. More than a decade ago, I published descriptions of a number of edible Philippine fungi and since that time I have every year paid some attention to this subject. Altogether, I have found about 150 species in the Philippines which can be eaten. There is a large Volvaria which grows spontaneously on abaca waste, and is commonly eaten in all abaca districts. This or a similar species of the same genus is cultivated on soil heavily fertilized with rice straw in Pampanga. One of our graduates, Mr. Arsenio Vicencio, made a study of this industry last year, describing carefully the methods used and the yield obtained. This work is now awaiting publication. There are at least two species of fungi which are generally eaten, and speaking in a rather loose sense, are cultivated in Pangasinan. There is also in all parts of the Islands a fungus which has many names, but probably no proper name, which is an article of culture by the termites (*anay*). At certain times, each year, this escapes from the termites and produces fruit above the ground, and this fruit is an excellent human food. Dr. Brown and myself have been studying this (-5-) for several years, and are almost ready to publish our results.

The work of the fungi as pests of crops is a subject of incomparably greater importance. The studies made by our class in Botany IV under Professor Baker's direction are in part a preparation for the study of these pests, and are in part an investigation of the pests and the damage which they cause. Professor Baker has several times pointed out that the damage done by these pests each year in the Philippines is greater in a monetary sense than is the whole income from such branches of industry as mining or forestry. We know too little about these pests in the Philippines to make a safe estimate of the damage, but judging from what we do know, and from more accurate information in other countries where these pests are no more conspicuous than we have found them to be here,

I have little doubt that their destruction amounts to more than $10,000,000 a year. They have destroyed the coffee business and cacao business which once throve in the Philippines, and are now doing more damage every year to rice and maize and our other crops than the coffee or cacao business was ever big enough for them to do by completely wiping it out. In a general way, these facts have been known for many years, yet the Government maintains a Bureau of Forestry, has maintained a Bureau of Mines, and has never had a single employee whose business was the investigation of fungus diseases.

What we do know about these diseases is almost entirely the work of this college. During the past year, one of our students, Mr. Fernando Luistro, has shown that the coffee rust can be controlled; and another student, Mr. Teodorico Ghofulpo, has made the same demonstration for the fungi which destroy the most of the fruit of our cacao trees. Both of these papers are now in press. Both as class work and as general unassigned work, we are continually collecting fungus pests (-6-) and finding out what they are. Two of our students, Mariano Raymundo and Simon Reyes, have developed remarkable ability in detecting these enemies. As a result of this work, Professor Baker has published in Elmer's Leaflets of Philippine Botany two long papers listing the minute fungi of the Philippines, with their hosts, and with references to all publications regarding them. He has also published in the Philippine Agriculturist and Forester a briefer list of the more important known fungus diseases of our cultivated crops. This study is going forward all the time.

In more detail, the class in Botany IV takes up the investigation of individual pests of the crops on our own farm. They have within the past two weeks discovered a pest (-7-) which at the moment is destroying a considerable part of our papaya fruit. This pest, a fungus named Phytophthora, is unable to injure perfectly sound fruit, but can attack a fruit injured in any manner, and promptly rot it completely. The recent baguios bruised the papayas sufficiently to make them susceptible, with the result that a large part of them are now decaying. Its work is so prompt that if papayas are bruised in collection, and then kept several days before marketing, they begin to rot, and in this way this pest is responsible for the bad appearance of most of the papayas on the Manila market. The obvious remedy for this difficulty is to take care not to bruise papayas in harvesting them. The same pest or another in the same genus has just been shown to be responsible for a large part of the injury to the local cacao; and it has already been demonstrated that on cacao the fungus can be controlled by spraying with Bordeaux mixture.

Among the many fungus pests detected here in recent months, those of the sugar cane should receive especial mention. There are at least three of these, all hitherto unsuspected, and all not merely dangerous but actually destructive. Among them (-8-) is a rind disease, very similar in its effects to the fearful rind disease of Hawaii, but caused by a different fungus.

The Department of Botany gives the same kind of basis for Forestry which it does for Agronomy, Forestry and Agronomy being regarded as the two great phases of plant industry. For the work in Forestry, we are particularly fortunate in that Dr. McLean is a trained forester with six years experience in the United States Forest Service. Because of his particular fitness for this work, we are now giving our students of forestry, as a part of their work in

Botany, instruction in the structure of trees, which is exceedingly important as training the students to recognize trees and their peculiarities in the field, and to understand the utility for various purposes of lumber and the minor forest products. For the past three years, there has also been carried on here a most important piece of cooperation between the botanists and the foresters, which has resulted in an understanding of the rate of growth of forest trees, and of the rate of production of timber, and has thus given to scientific forestry in the tropics a better foundation than it has ever had before in any place. On the botanical side, this work was performed by Dr. Brown, at first as an employee of the Bureau of Science, and afterward at the same time that he was teaching Botany in the college.

Chemistry

Chemistry is the other scientific basis of agriculture. In American colleges, Chemistry has always been the principal scientific basis of agriculture. In the Philippines, we have given Botany the foremost place, but of course retain the teaching of Chemistry as a matter of very great importance. In our classes, we teach one year of general Chemistry, and a second year of Chemistry in particular application to agriculture. There is also a small class of advanced students studying the Chemistry of particular agricultural products, such as sugar, the commercial oils, starch, etc.

A number of our students, in preparation for graduation, have carried on research in particular chemical problems. Among these may be mentioned the most complete study ever made of the food value of gabi and related crops; a study of the chemical changes in ripening sugar cane, intended to bring out clearly the time at which cane can most properly be harvested; a study of the chemical processes which take place in ripening coconuts and germinating coconuts; a study of the fixation of nitrogen in soils by leguminous plants, and another study of the same process as carried on by bacteria independently of higher plants; a study of the loss of fertility which results from burning over land, as in the case of grass fires; and a study of the production of camphor by the young camphor trees in cultivation here. While all of these have yielded results of practical value, the most important have been the study of nitrification in soils. Due to the heavy rainfall, Philippine soils are everywhere, except in the virgin forest, deficient in nitrogen, and respond readily to the application of nitrogenous fertilizers. Commercial nitrogenous fertilizers are decidedly expensive. This work of our Chemistry Department, done in connection with the study of crops by the Agronomy Department, has shown that a considerable number of our crops fix nitrogen in the soils, and so, in varying lengths of time, make the application of commercial fertilizers entirely unnecessary.

The Department of Chemistry is also continually being called upon for analysis of both soils and products for the information and guidance of the Department of Agronomy. Experimentation in many phases of agronomy is quite impossible without the collaboration of the chemist. For this reason, the Department of Chemistry is as strong even as the Department of Agronomy itself in many of the American experiment stations. The maintenance of experiment stations without chemical facilities, as has been tried here in the Philippines, could never reasonably have been hoped to give satisfactory results. The establishment of a considerable number of well equipped chemical laboratories would be decidedly expensive, and the

employment of a number of chemists to work separately would be wasteful. This is one of the most important reasons for the concentration of experimental work in a single place. Our Bureau of Agriculture has been dependent on the Bureau of Science for this kind of service, and the files of both institutions are full of evidence that the attempt to have the experiments carried on under one office, and the chemical investigations under another one, has been a constant source of friction and inefficiency.

The investigations now being made in our chemistry laboratory, which have already gone far enough to begin to yield positive results, include:—A study of the oil (-9-) in the seed of Leucaena glauca (ipil-ipil); a study of the efficiency of Philippine methods of extracting or expressing coconut oil (-10-); an investigation to determine the time of maximum starch content of *camoteng cahoy* (cassava) (-11-); a study of methods of determining soil acidity (-12-), and of the acidity of local soils; and a study of the various locally available compost materials (-13-), to determine how much nitrogen they furnish for the use of crops.

Entomology

Entomology in its purely practical aspects is a simply enormous subject. While the Government of these Islands has not neglected it as it has mycology, to the extent of never employing a single man of trained practical ability, it is still true that the Government has never taken into its employ any entomologist with training comparable to that of the various botanists and chemists. Of the men who have been employed, perhaps half a dozen in number, none except Mr. Banks has been in the service long enough to develop efficiency and remains in our service now. Hawaii with its incomparably smaller field employs nineteen entomologists, and has for decades been employing a large staff of trained men in this field. It is no wonder then that the most of what we ought to know about entomology (and the most of what we ought to do in Entomology) is not even a closed book, because it is a book which has never been written.

Entomology, like mycology, has two opposite aspects, one constructive and one destructive. On the constructive side, there are many insect products, of which the two most important are silk and honey. With honey, we have never been able to make the beginning, for want of the necessary personnel. With silk, we have for a number of years maintained cultures of the worms obtained from the Bureau of Science. This has been done purely for the training of our students, and there has been no attempt to do any research work here.

As to the damage done to crops and to animals by insects, our knowledge is only fragmentary, but is sufficient to indicate that this is even greater than the damage done by fungi. Until a year ago, our Department of Entomology was a purely teaching department, and a considerable part of the time of the one teacher, Mr. Ledyard, was required for assistance in the administration of the College. Since Mr. Banks was transferred to the college, and especially since the entomological collections and library of the Bureau of Science were brought here, there has been a radical change in this respect. Our students have always collected many insects, both as part of Mr. Ledyard's class work and under the personal stimulus given to this activity by Professor Baker. This work is now going on with greatly increased activity, and new pests (-14-) are constantly being discovered and investigated. Our students in Ento-

mology have already received enough training in Agronomy to have an active and particular interest in the pests of crops, and the study of Entomology is carried on with constant reference to the activity as pests of the insects studied. In this way, the general class work results in a constant increase of our knowledge of insect pests.

Beside this general class work, there are a number of individual problems which are receiving particular study by single students or groups of students. Among these, as those which have already yielded some results of positive value and are being carried forward with a view to publication, may be mentioned the study of insect pests of tobacco (-15-); certain insect pests of rice (-16-); certain insects attacking gabi (-17-) and its relatives; a few of the many serious insect pests of sugar cane (-18-); the flies and other insects attacking several of the local fruits (-19-); and a biological study (-20-) of the habits of termites (*anay*). While this work is focused at Los Baños, the fact that our students come from all parts of the Islands makes it possible for us to constantly collect insects and information regarding insects from many localities; and as our students graduate and return to their provinces, we have a guarantee that the practical results of these studies will be effective all over the Archipelago. This argument, of course, applies with equal intensity and in a much larger way to the work of our departments of Agronomy, Animal Husbandry, and Forestry.

As a result of the activity of this college, it becomes year by year a better place for investigation, and as our work becomes known abroad, scientists can be expected to come here to study; and in every such case, we, who supply facilities for study, instead of losing anything when outsiders take advantage of what we have to offer, gain by whatever our visitors are able to discover. As an example in point, Mr. Muir, a most competent entomologist, employed by the Hawaiian Sugar Planters' Association, has been working here for several months, and one of his colleagues has recently joined him here. Beside giving us many useful suggestions, Mr. Muir has called our attention to a number of previously unnoticed insect pests, including the deadly sugar cane borer of Java, and another destructive borer attacking the same crop. In connection with the enforcement of our recent agricultural quarantine law, it beseems us to know something about what pests are already within our gates.

Agricultural Engineering

For one brief period, this college enjoyed the services of one thoroughly trained and competent engineer. The importance of the subject in a land where machinery and its application to agriculture are not much better than unknown, but are sorely needed, is of the most manifest importance. When Mr. Glodt resigned, the best that we could do was to assign his work to Mr. Cuzner, himself a well-trained man in certain phases of agriculture and forestry, and with somewhat more than the usual incidental training in engineering. This arrangement has the exceedingly desirable result, that the work we do in engineering is constantly and intimately related to the application of engineering to agricultural problems. But while it does this, it of course promises very little assistance in the development of agricultural engineering as a distinct industry.

The college has never had a special teacher for the very important subject of agricultural physics, and the majority of our students come here without any previous training in general physics.

Under these conditions, instruction in physics has had to be assigned to the Department of Engineering, and the physics alone ought to receive the whole of a man's time. Our college work in engineering is still more seriously interfered with by the fact that for several years all permanent improvements on our campus have been made under the immediate direction of our own engineer. This has the advantages that the work seems to be cheaply done (for which the Bureau of Public Works has received the public credit), and that such permanent improvements as have been made here have been made with the best possible application to our needs. But this service of our engineer takes so large a part of his time that it has done no good on the whole to the work of his classes.

The principal work of our Engineering Department, then, aside from instruction which is itself inadequate, has been the construction of buildings and temporary roads, the repair of our water system, and the incidental repairs and alteration of buildings and construction of furniture and equipment which are constantly required in an institution of this kind. While this has gone on, it has been possible to devote a little attention to the construction of concrete irrigating ditches, the terracing and mapping of land, and other related projects. On the whole, however, there has been less of this work done than was demanded, and what has been done has not been carried to completion, and the whole subject of agricultural engineering has received altogether inadequate attention. This is not a reason for criticism of Mr. Cuzner, but has been the inevitable result of assigning to one man work which three men would have found difficult. In this respect, the Department of Engineering has not been very differently situated from our other technical departments.

Agronomy

The Department of Agronomy, according to our organization, includes all agricultural work with plants. In most institutions, this field is broken into two or more, Agronomy retaining only the field crops, while the orchard crops fall to the Department of Horticulture. In many places the division goes much further than this, so that there are separate departments for garden crops, for ornamental plants, for such crops as sugar which require particular service from other departments (in this case, Chemistry), etc. In my opinion, the simplest practical organization is both cheapest and most efficient. It has, therefore, always been the policy of this college to have as few independent departments as possible. In this respect, the Bureau of Agriculture has followed our example, and abolished its former division of Horticulture.

The staff of the Department of Agronomy consists of Professor Baker, Assistant Professor Cocannouer, Instructor Elayda, Mr. Mendiola as a graduate assistant, five graduate scholars, several undergraduate assistants and one clerk. A similar institution in the United States with about the same number of students would have from eight to fifteen men of professorial rank, as compared with our two; and there is no agricultural college in the United States which has turned out as much finished experimental work in the past year in the field of Agronomy as our own Department of Agronomy has done. There is no question in my mind that American colleges have too many professors. So far as students about to graduate, and students who recently have graduated, are able to perform the routine of research satisfactorily under the direction of the professor, results are obtained much more economically and on the whole more intelligently if the work is

done by a large number of advanced students under the direction of the best man whom money can secure, than they are if the money is used for the employment of a considerable number of men of fair or good ability, who are supposed to have been trained to work independently.

Aside from economy in securing immediate results, our system has the incalculable advantage, that it constantly trains our students to do work of a kind for which they are not trained by the American system. When one of our students graduates, he must already have demonstrated that he is or is not naturally fitted for investigation. We are, therefore, able to select, on the basis of previous demonstration, those of our graduates who are best fitted to devote themselves permanently to this kind of work, and to put them at this kind of work as graduates, with previous training for such service which they could not have obtained in an American college. The result is that we have already made a very respectable beginning in the training of Filipinos for service of this kind. We are taking no chances, and are not forcing progress because of Government policy, but are acting solely on the basis of demonstrated fitness and ability, in training Mr. Roxas, Mr. Gonzales, Mr. Mendiola, Mr. Quisumbing, Mr. Raymundo, and several other students not yet advanced enough for individual mention, as future University teachers and leaders in agricultural investigations. The marked progress which we have in the past few years made in this direction is a pure function of the peculiarities of our course of study. If our curriculum had been modeled after those of American colleges to the extent which President Waters recommended last year, the results which we have obtained would have been absolutely impossible.

But, while the American colleges waste their money in one manner, we have developed decidedly too far in the other direction. There are nearly forty students working on single investigational problems in our Department of Agronomy at the present time. Professor Baker and I are our only men of tried ability to supervise this kind of work, and my other work, as Dean and Professor of Botany, leaves me almost no time to assist Professor Baker. I do not think that any man, even Professor Baker, can oversee more than twenty separate pieces of investigation, and give each one the necessary attention. It is very probable that a year from this time the number of students working on separate problems will be more than fifty. For the supervision of this work, our Department of Agronomy must have more men of thoroughly first class training and ability. Professor Baker's record here is the best demonstration which could possibly be desired of the magnificent returns which the Islands secure from the employment of absolutely first class men, and not of a larger number of good men.

Understanding that Agronomy is, for the purposes of our students an art rather than a science, and that it is the primary business of this college to train its students to be successful farmers, and that it is the Department of Agronomy upon which we are primarily dependent for success, the instruction given by this department is from the beginning made thoroughly practical. How true this is, must be evident from the list of practical problems and operations required of all our students. As stated in the catalogue, these are:

A. Farm Accounting.

B. The handling of labor.

C. Work with hoe, rake, spade, and fork; cleaning of garden paths, drives and walks; preparation of beds.

D. Work with Planet Junior hand tools.

E. Sharpening of all small edged tools.

F. Oiling, cleaning, and care of machine tools.

G. Preparation and handling of seed beds; pricking out of young plants in nursery beds and flats; setting out young plants.

H. Plowing, from the use of small plows with single animals to heavy moldboard and disk plows.

I. Machine harrowing, marking, and cultivating.

J. Broadcasting and planting with machine planters.

K. Harvesting and cleaning seeds.

L. Management of compost and manure heaps.

M. Marcottage and making of cuttings and layers.

N. Mixing and hand and machine application of fertilizers.

O. Planting young trees and moving older ones.

P. Tree and shrub pruning.

Q. Budding and grafting, including preparation of wax and tape.

R. Seed grading and selection.

S. Production of inbred, crossbred, and hybrid seed.

All of this work is now being given, with the exception of proper methods of harvesting and the machine application of fertilizers, which we are unable to give for want of equipment. To this list of practical subjects, we desire to add a moderate amount of practical carpentry and blacksmithing, and have secured the approval of the University Council to this addition, and the work will be done whenever we can secure the equipment.

There is no agricultural college in the United States which requires approximately as complete a program of practical work as is ours. In view of this fact, the criticism occasionally made that the work of this college is not as practical as it ought to be is simply ridiculous.

In the class work of our Department of Agronomy, a part of the time during the first year is occupied with the explanation and demonstration of general principles, such as the study of the chemical and physical properties of the soil. After these general principles, the crops of the Philippines are taken up individually, one after another, for thorough treatment in classroom and field. The nature of the instruction regarding each crop can be gathered from the catalogue statement regarding the coconut; "Covering as much of its physiology as has direct agricultural value; its diseases and their treatment; all steps in its proper cultivation, harvesting, and preparation for market, in the Philippines and elsewhere; and the uses and value of the products."

As the final step in the students' training, each candidate for graduation is required to submit a thesis which presents the results of a special study, representing a year's work on some specific problem; and this work must yield results which we regard as worth publishing. The publication of these results has up to this time been at the expense of the student body itself, and without expense to the Government; and the body of information already published in this manner is by far the most comprehensive body of such information regarding Philippine agriculture which has ever been produced. The preparation of these theses is of course for the sake of the students. The thesis is required because it is expected that after graduation the young men, as farmers, will meet problems which they are obliged to settle for themselves; the preparation of the thesis is the training we give for handling such problems. It is merely incidentally that we do secure

from these theses information of scientific and practical value, and the information so obtained is a clear gain, which the Filipino people secure without any direct expense whatever for the purpose.

In the experimental work of the Department of Agronomy, the majority of the problems have regard to individual crops, but there are a few which deal with more general problems. Examples of the latter class are the study of the relation of mulches and of methods of cultivation to the amount of water which the soil is able to retain, regarding which a study has been published by Mr. Eladio Sablan (Philippine Agriculturist and Forester, 4 (1915) 51); and the study of the propagation of a considerable number of trees and vines by cuttings and by marcottage, regarding which Mr. José Miraflores has published his thesis (Philippine Agriculturist and Forester, 4 (1915) 142). The study of the economic status of rice production made by Mr. Catalino G. Aurelio is another example of a rather general problem. Of the same general nature are the study (-21-) of methods of controlling erosion, both by mulches and by drainage; and the study of local gardens (-22-), and of the profits from local gardens, which studies are now being carried on. As work of the most general utility in the scientific understanding of agricultural conditions should be mentioned the study of local weather and climate, which was begun by Dr. Brown as work of the Bureau of Science, but is still being carried on here under the personal direction of Dr. McLean.

We will now take up one by one the crops which are subjects of demonstration and investigation by our Department of Agronomy.

The Coconut

Because I had been occupied with the study of the coconut before this college was established, and because we bought the land of the college with young coconut groves already present, this was the first staple Philippine crop on which our instruction and practical field work were well organized. Our investigations of this crop have included the following subjects.

First:—Varieties.—Beside the local variety, which seems to be very uniform, we have secured and planted seeds of the very large San Ramon nut and of a number of varieties from Leyte and Pangasinan. These were of course obtained as seeds and are still only young trees. When they mature, we will have material for a comparison of varieties (-23-) such as has never been made in the Philippines, nor in fact anywhere else except in Madagascar.

Second:—Germination and the Care of Seed Beds.—Our students have been given practice on these subjects during every year since the college opened, and some information of value has resulted from their experiments. It has been demonstrated, for instance, that during the months from June to September, the highest percent of germination is obtained by placing the nuts on the surface of the ground in the shade, while during the remainder of the year, germination is more complete if the nuts are three-fourths buried. A very careful study of seed bed technique (-24-) is now being made by one of our senior students, Mr. Bacomo. He has found that by proper preparation and cultivation of the seed bed, germination can be made very much more rapid than has been supposed, and that the best results are obtained by leaving the seed nuts in the bed only about half as long as is the usual practice.

Third:—Transplanting.—Our work on this subject has verified results already obtained in other countries, show-

ing that it is good business practice to prepare a hole about 40 centimeters in diameter and to place rich soil around the young seedlings. It has been found, however, that the preparation of much larger holes, as is recomended in Ceylon, will not pay in the Philippines. The behavior of seedlings transplanted at different ages and with different weather is also being studied by Mr. Bacomo. We have demonstrated that it is practicable to fill occasional vacancies in young groves by transplanting trees up to the age of least six years, but that trees so transplanted are especially subject to attack by the black beetles.

Fourth:—The use of Fertilizers.—Experiments with commercial fertilizers have shown us that results can be observed within six months in the form of more rapid growth, but that no effect on the production of nuts can be detected until after one and a half to three years. From this observation, we know that the few results which have been published regarding increase in yield due to the application of fertilizers in the Philippines are absolutely valueless, because the supposed increase in yield was observed sooner than the fertilizers could possibly have caused it. We have used one of our groves for cattle pasture and corral, and have found that the yield of nuts, two years after this use began, was fully doubled.

Fifth:—Diseases.—Before this college opened, I had planned a campaign and secured the necessary legislation which resulted in the practical eradication of bud rot from the Laguna towns where it had threatened to destroy the entire coconut industry. Our coconut students visit this district every year and make a search for occasional trees which still exhibit bud rot, and destroy some of these trees by fire, for the sake of practice, and report all others to the local officials. By these annual visits, we are able to prevent this most destructive pest from reassuming dangerous proportions. Mahayhay, Lilio and Nagcarlang are, because of the local climate, in much greater danger of bud rot than are Tiaong and Candelaria. Nevertheless, we have constantly restricted bud rot to the point of practical harmlessness in the Laguna towns, while in the Tayabas towns, which we have not visited, this pest has recently been exceedingly destructive, according to the reports of the Bureau of Agriculture.

One of our students, Mr. Roxas, made a careful study several years ago of the possibility of preventing damage by coconut beetles by means of chemical poisons. His conclusion was that, while with certain poisons it is possible to kill the beetles without damaging the tree, this method requires too expert technique to be recommended for general practice. The study of the life history of beetles has shown that the red beetle matures in from one-eighth to one-quarter of the time stated in previous publications by the Bureau of Science; and this difference in time demands wholly different practice in preventing damage by the red beetle. Our observations seem to prove that the red beetle enters trees as a result of fire, or artificial damage, or injury by storms, or of the previous attack by the black beetle (*uang*). The methods to be followed in preventing damage follow obviously from the facts just stated, and we have shown that these methods are effective. The black beetle breeds in any kind of decaying matter, animal or vegetable; it can be controlled by keeping all decaying matter out of the neighborhood of the coconut grove. The red beetle breeds only in palms, but can not enter sound trees; the only way to control it is to keep all trees sound.

We have found in the Philippines every important fungus diseases of the coconut known in the world, and have recently discovered still another fungus which is apparently new. The most of these fungus diseases weaken the trees and so reduce the crop, but are not fatal. Healthy trees suffer hardly at all from fungus diseases. The best way of handling these diseases is therefore to see that the trees are constantly strong and healthy. This is to be accomplished by keeping the groves clean and preferably somewhat cultivated, by the use of fertilizers if the ground is very poor, and by the use of water if the ground is very dry. It is not good practice to plant coconuts on ground that is likely to become very dry.

Sixth:—The Physiology of Coconut.—We have made a study of the growth of the coconut more thorough than was ever given the growth of any other cultivated crop in a single place. Altogether, we have more than one hundred thousand determinations of the rate of growth. The study of such extensive data has enabled us to establish a relation between rate of growth and production of fruit, and to determine with a high measure of accuracy what the production of fruit from any individual trees or grove of trees will be two or three years hence. By the use of this information, I was able, as soon as the coconut crop of Laguna failed in 1913, to answer the question of a Manila business house as to when good crops might be expected again, and the forecast proved to be a very exact one. Such a forecast could not have been made for any other crop in the world with the same measure of confidence and precision. If we had no evidence except this single case, by which to demonstrate the importance of thorough work in plant physiology as the basis of agronomy, the prominent place which we give to plant physiology in our work here would still be amply justified.

Ten years ago, I undertook to determine a relation between the climate (sunlight, wind, rain, and atmospheric humidity) and the absorption of mineral food from the soil by coconuts. Working by myself at San Ramon, without laboratory facilities, I was unable to secure results as conclusive as were wished. A large part of this work has been repeated here in a manner which makes our results completely trustworthy. This illustrates again the dependence of satisfactory work in Agronomy upon the facilities of the laboratories for Chemistry and Botany. We know now that a coconut may fail to secure sufficient mineral food from the soil even though plenty of such food is present in the soil, and that in such cases, the application of fertilizers will be almost useless and certainly unprofitable. The real trouble is most frequently that the coconuts are planted too close together. Coconuts in the Philippines are frequently planted as closely together as six meters, while a distance of less than nine meters results not merely in fewer nuts from each tree but in less production from a hectare of land. If trees are ill-nourished because too close together, neither fertilization nor irrigation would be profitable. The best thing to do is to remove a quarter of the trees and so let the remainder secure a reasonable amount of sunlight and wind; if this is done, the trees which are cut down should be destroyed in order that their trunks may not be a breeding place for beetles.

Seventh:—Utilization.—The copra marketed through Manila ranks with that of two or three other places which are minor source of the world's copra, as the poorest copra which goes onto the world's market. Manila receives

annually fully $1,000,000 less for its copra than it would receive if our copra were first-class. On our grounds, we have experimented with the native "tapahan" method of drying and with a German dryer. By the tapahan method, we can improve the quality of native copra by constant drying at a lower temperature than is usual. But the constant drying is arduous, requiring care during the night; and even with the best care, this copra is not really first-class. With the German dryer, we can prepare copra fully as good as any in the world, but the use of this dryer can still not be recommended, because of its small capacity. We have had an opportunity to observe the work of three very distinct types of copra dryers, tested commercially in Laguna in recent years, and to observe less carefully the work of some of the other dryers which have been tested elsewhere. The conclusion from these observations is that a dryer invented by Antonio Navarro of Pagsanjan is well suited for Pagsanjan conditions. In places where it is practicable to assemble nuts in very large quantity, this dryer is a practical one and produces perfect copra. It is doubtful if the same type of dryer would prove practicable in places where the assembling of a very large quantity of fresh nuts would be difficult. The Bonito dryer, of which several have been in use in Laguna, can be made to produce first class copra; but the copra which is placed on the market from these dryers is dried at too high a temperature and too rapidly to be of high grade. If the temperature in this dryer is kept lower, so as to produce first-class copra, the use of steam ceases to be as economical as that of hot air would be, but can still be made practical in a business sense, if the power furnished by the steam engine can be used for the manufacture of marketable coir.

Eighth:—The Economics of the Coconut Business (-25-).—In Philippine agriculture, it is almost unheard-of for books to be kept with such care that the farmer knows what his produce is actually costing him, and it is therefore impossible for him to know what profit his business is paying. Under these conditions, it is impossible for him even to know what his plantation is actually worth. In this province, coconut groves are sold or sales are refused practically without regard to their actual producing value. I have personally known groves to change hands at prices ranging all the way from ₱1.00 a tree to ₱10.00 a tree, and have known offers above ₱10.00 a tree to be refused. The condition of any business, even a temporarily profitable one, is unsound so long as there is no valid method of determining the value on which a percent of profit should be calculated. And under the same conditions, it is impossible for the Government to have a valid basis of taxation. We attempted last year to secure complete information regarding the entire plantation costs and returns from forty coconut groves in this province. As far as possible, we secured information as to the investment which these groves represented and as to the probable duration of future life of the trees. From these figures, we attempted to make a proper allowance for depreciation, up to the time the trees would die, and to determine the present actual value of the groves, trees and land together, assuming arbitrarily that interest was worth 5%, 10%, and 15% on the investment. Because the figures we were able to secure from the farmers in most cases were inadequate in one respect or another, this study is not considered complete, and is being continued this year. One interesting result, however, is already clear; although the coconut business

is regarded as exceedingly profitable, still, if we accept the estimates of the owners as to the present value of their groves, their annual returns, in interest on this valuation, are almost never as high as the local interest rates on money itself. In other words, if they could sell their plantations at what they think these plantations are worth, they ought to do so and place their money at interest. This collection and analysis of business statistics from individual farmers will be kept up even after our conclusions are definitely established, because it is exceedingly valuable business practice for the students who collect and audit the statistics.

The publications already made regarding coconut work done in this college or embodying results of such work, are as follows:

Physiology of the Coconut, by E. B. Copeland, Philippine Agriculturist and Forester, *1* (1911) 44.

The Cultivation of Coconut, by Manuel Roxas, Philippine Agriculturist and Forester, *1* (1911) 57. (This is a translation of a paper read in Spanish by the writer in the agricultural conference held during the Carnival, 1909).

The Makapuno Coconut, by B. M. Gonzalez, Philippine Agriculturist and Forester, *3* (1914) 31.

The Changes Occurring in the Ripening Coconut, by B. M. Gonzalez, Philippine Agriculturist and Forester, *3* (1914) 25.

Lipase in the Germinating Coconut, by M. Roxas, Philippine Agriculturist and Forester, *3* (1914) 33.

Experiments on the Coconut, by E. B. Copeland, Philippine Agriculturist and Forester, *3* (1914) 121.

Chemical Changes in the Ripening Coconut, by T. Vista, Philippine Agriculturist and Forester, *4* (1915) 109.

The Coconut, by E. B. Copeland, Macmillan & Co., 1914. (This book serves as a text for our class studying this crop.)

The account already given shows the variety of studies of the coconut which are now under way here, and on which the publication of results will be made from time to time as different single studies are completed.

Altogether, the amount of work which has already been published from this college is the most comprehensive which any institution in the world has ever been able to give out on this subject.

Fiber Plants

The College of Agriculture is not located in typical abaca country, but the crop can be produced here on the sides of cañons, and on more level ground at higher altitudes on the slopes of Mt. Maquiling. When the College opened, there were a few dozen plants already in cultivation here. These were of the typical Laguna variety which produces small plants and a low yield, but fiber of excellent quality. We have since secured plants of the four principal Davao varieties and of several Leyte varieties. We have this year secured the use of land on the forest reserve already planted to abaca, where we have about 5,000 hills of the native variety. The comparatively few plants of other varieties have recently been transplanted to this location. Our work with abaca has been very much less thorough than that with coconut, but has taken up the following subjects.

First:—Varieties (-26-) as already mentioned.—Our collection of varieties is still very incomplete but is nevertheless more ample than any which has ever yet been the subject of comparative study and publication. All our Davao varieties grow more rapidly, mature more quickly, and yield more fiber than does the local variety. Three of the Davao varieties are more than twice as productive of fiber as is the local one.

Second:—Reproduction.—A study of reproduction by suckers, which is not yet complete (-27-), has shown that it is better business practice to use suck-

ers about ten centimeters in diameter, as is usual in Davao, than it is to use suckers not more than five centimeters in diameter, as is more usual in Laguna. The plant can also be propagated by means of rhizomes, but this method is not practicable as farm business. Abaca can also be reproduced by seed, but a considerable number of experiments here do not show that this method is ever advisable.

Third:—Diseases.—We have discovered a number of fungi which live upon abaca but none of these do considerable damage to healthy plants. If abaca is grown in too dry a situation, it is weakened so that fungi injure it seriously; but it is not good business to attempt to raise abaca in such places. Extensive damage is being done to the abaca in the vicinity of Paete by the larvae of an insect which lives in stems, both underground and erect, and which stunts the plants so that they produce very short false stems and too little fiber to make the crop profitable. The life history of this insect (-28-) is now being worked out in our Entomology laboratory.

Fourth:—The Physiology of the Abaca.—An extensive study of the growth of abaca in sunshine and in varying degrees of shade, during the rainy season and the dry season, has been made as a part of our class work; and Mr. Felipe Cevallos has published an intensive study of the same subject involving more than 16,000 determinations of rate of growth. The conclusion from this work is that in seasons as dry as we have here during the most of the years, abaca exposed to full sunshine, and without irrigation, suffers so much that its cultivation is impracticable in a business sense. On the other hand, during fully half of the year, while there are at least occasional rains, abaca exposed to full sunshine grows much more rapidly than it does if even partially shaded, and besides growing more rapidly produces a larger percentage of fiber in the trunk. The conclusion suggests itself very strongly that, speaking for the Archipelago as a whole, it would be the best economic practice to develop the abaca industry only in those regions where the climate is constantly moist enough so that abaca can be grown without any shade whatever. Figures furnished me privately by a thoroughly responsible Davao planter show that he has harvested at the rate of 68 piculs of first class fiber per thousand hills and per annum. It is unusual for shaded abaca in any part of the islands to produce as much as 20 piculs per thousand hills. The production of fine fiber, to be marketed as knotted fiber, in Laguna, Batangas, and Cavite, is certainly profitable. But our experiments have forced us to the opinion that these regions can not compete in the production of cordage fiber with those districts where shading does not need to be practised.

Fifth:—Harvesting.—A study of the amount of fiber secured from individual stalks of varying maturity has shown that the amount of fiber increases steadily up to the time that the flowering bud appears, but that after this time there is a decrease in the amount of fiber, which becomes very rapid from the time that the flowers open. These observations justify the usual Filipino practice of harvesting stalks one at a time from each hill as the plants approach the time of producing flowers; the less usual practice of attempting to harvest many trunks at a time, and so to go over the fields at longer intervals, involves a great loss of fiber.

Inasmuch as the banana and abaca are very closely related, and as attempts have been made to produce a marketable fiber from banana stems in other

countries, we have extracted and tested the fibers of some of the banana varieties. Both *saba* and *butuan* produce a fine fiber of excellent appearance, but neither one of these produces enough fiber to give it any promise of competition with abaca.

With the plants of the maguey group, we have never made any extensive experiments. For the sake of preliminary observations and to furnish materials for possible future experimentation, we are cultivating, on a small scale, the local maguey, a related species from Cuba, the sisal of Yucatan and the West Indies, and Mauritius hemp. Of these, the last mentioned exhibits by far the most luxuriant growth. But under local conditions, it seems probable that none of these are worthy of cultivation. Bowstring hemp is being tested in the same manner.

Coir, the fiber extracted from the husk of the coconut, is an article of such varied uses and such considerable commercial importance that the idea of producing it in large quantities in the Philippines has been agitated repeatedly. We have extracted this fiber at various times and from nuts of various degrees of ripeness. Some of the fiber has been good enough to receive first prize at the Philippine Exposition. However, we have not been able to show that it is feasible to produce this on a commercial scale in the Philippines and have come rather to the conclusion that it is not possible. The most of the coir of commerce is produced in Ceylon where labor is much cheaper than it is in the Philippines. At the Magdalena copra dryer, coir has been produced by the use of surplus power from the engine which heated the dryer, but this product was of too poor a quality to become an article of export.

In certain localities in the Philippines, cotton is produced and used. We have made tests here of several varieties of American cotton, and under most favorable climatic conditions have obtained a yield which could be considered profitable. On the whole, however, our cotton has been checked in growth by excessive rain or dryness, and has been very seriously infested by several different insects and fungi. With such yields as we could obtain, it would not be commercially feasible to prevent the attacks of these pests. There is a perennial cotton, of which we obtained seed from Tarlac, which produces a plant three or four meters in height, which is almost immune to the pests of the imported annual varieties. *A priori*, it seems probable that a hybrid can be produced by crossing the imported long staple cottons on the local Tarlac species, and that from such hybrid it should be possible to select a strain which will be perennial and in high measure productive and disease-resistant. Our attempts to produce such a hybrid promised success at first, but were afterwards abandoned, because we had not enough men to devote adequate attention to this problem.

Of the general class of fibers known as "bast fiber," including hemp, jute, flax, etc., there seems to be an annual importation into the Philippines, amounting on a average to about ₱230,000. The most of this material comes from tropical countries and we have hoped to find a means of developing an industry here which would put a stop to this importation. Experiments with ramie (China grass) showed at once that the plant would reach a size here in three months which requires a year in China. As soon as this was demonstrated, we undertook to produce ramie on a field scale, but a series of attempts has shown us no way of preventing precocious flowering. The plants produce flowers, as a rule, at a height of less than one meter,

and immediately cease to grow. As ramie of this size can not be handled with profit with labor as expensive as ours, we have given up this project. The biggest single item of imported bast material is made of the products of jute. Jute grows wild in the Philippines, and has seemed to offer a promising subject for study. After two years of general attempts, we had one of our candidates for graduation, Mr. Sotero Albano, make a very thorough study of it, testing the effect of different distances in planting, different preparation of ground, and the application of water, the use of fertilizers, and even the use of chemical stimulants. The final conclusion has been that, although it is possible by the best treatment to secure a yield of jute which would be economically profitable in India, the same yield can only be produced and utilized here at a financial loss, because of higher price of labor.

There are a very large number of native plants which in different places in the Philippines are locally used as sources of fiber. Besides class studies of these plants, extending over several years, a very thorough study of fourteen of them has been undertaken this year by Mr. Nemesio Mendiola (-29-) in candidacy for his master's degree. His work on eleven of these has been practically finished and shows that most of them offer no promise of anything more than local use. The results with a few are encouraging enough to offer somewhat definite promise of commercial value. Among these, the most promising is *Abroma augusta*, known locally as *anabo*. The fiber of this plant is already an article of appreciable local importance in the Sarangani District of Mindanao.

Work published from this college in the past on fiber products is as follows:

Abaca, by E. B. Copeland, PHILIPPINE AGRICULTURIST AND FORESTER, *1* (1911) 64.

The Effect of Shade on the Environment of the Abaca Plant and on the Plant Itself, by Felipe Cevallos, PHILIPPINE AGRICULTURIST AND FORESTER, *1* (1911) 161.

The Effect of Fertilizers and Stimulants upon Growth and Production of Corchorus Capsularis L. (Jute), by Sotero Albano, PHILIPPINE AGRICULTURIST AND FORESTER, *3* (1915) 218.

Mr. Espino's paper on abaca is ready for the printer, and Mr. Mendiola's work on native bast fiber is almost completed.

RICE

The College of Agriculture began active rice work when it was established. Without either paddies or irrigation system on the farm, our efforts have been largely given to upland varieties. A series of selections (-30-) are under way and also experiments (-31-) with fertilizers. As rapidly as desirable selections are obtained, they are planted in test rows and carefully studied. The most valuable strains will be propagated in field cultures and the improved seeds will be available for distribution through the students and otherwise. Just at this time Mr. Jacobson of the Bureau of Agriculture is cooperating with us in this important work. Up to this time our work in paddy rices has had to be done largely in the adjoining rice regions of Calauang, Bay, and Calamba, and certain aspects of this work will be continued in these fields, in any event.

With the upland rices we have also made progress in an extensive series of cultures calculated to throw light upon methods (-32-) of culture, rotations, and fertilization, and these are being to some extent cooperatively extended by means of thesis students, among adjoining farms even as far as Calamba. Of paddy and upland rice together, we have had under experimental investigation at the college more than 400 of the best Philippine varieties. This year we

have just concluded a considerable series of experiments in which comparisons were made between the native methods of planting upland rices and caring for the culture, and methods of culture in which the rice is planted by drill at various distances and cultivated solely by machine cultivators. With the previous paucity of exact data in connection with rice, it has been very difficult to get rice work into proper instructional form. As a result of two years of the constant labor of Mr. Rundles, in cooperation with Mr. Jacobson of the Bureau, we now have, for the first time, a preliminary draft of an advanced course of instruction in rice work.

This year we have found in this region several very serious insect pests not before reported from the Islands, attacking the stems of rice and also the leaves, and besides these a serious root louse which lives in large colonies on the roots of the plants, from which it sucks the juices. We are studying these pests with a view to discovering if possible some remedy therefor. We also have under constant observation a number of serious fungus diseases (-33-) of rice.

There has never yet been, either in the Philippines or in any other country, so critical a study of rice varieties as to enable students to certainly identify a given variety, apart from the local knowledge of growers. At the recent Rice Congress held in Spain a resolution was adopted calling attention to this fact and stating this work to be of most critical importance at the present stage of development of rice growing. A rice variety may have different names in different provinces, and really distinct varieties may bear the same name. It is rarely possible to find a pure culture under any name. There is scarcely any doubt whatever that numbers of the varieties now being extensively experimented with in Indo-China, Siam, and other countries are identical with some of those being raised in the Philippines. Any proper coordination of experimental work must of necessity depend upon far greater positive knowledge of the identity of the rice varieties. During the past year one of our advanced students, Mr. Octubre, has completed a very extensive piece of work on the subject, covering 60 of the most important of the Philippine rices. This will be published later.

Publications by the College on the subject of rice are:—

Rice Growing in Pampanga, by Felix Franco, Philippine Agriculturist and Forester, *1* (1911) 7.

Leptocorisa Acuta (a rice pest), by José Zamora, Philippine Agriculturist and Forester, *1* (1911) 8.

The Effect of Some Stimulants upon Rice, by Manuel Roxas, Philippine Agriculturist and Forester, *1* (1911) 89.

Fertilizers and the Growth of Rice, by José Zamora, Philippine Agriculturist and Forester, *1* (1911) 152.

The Growth of Rice in Water-Culture, by Valente Villegas, Philippine Agriculturist and Forester, *2* (1912) 86.

Cultural Notes on Upland Rice in the Philippines, by Marcelo Crisostomo, Philippine Agriculturist and Forester, *3* (1914) 111.

Rice Judging and Study, by J. C. Rundles, Philippine Agriculturist and Forester, *3* (1915) 181.

The Cost of Rice Production by Philippine Methods, by Catalino G. Aurelio, Philippine Agriculturist and Forester, *4* (1915) 29.

A second study by Mr. Rundles is now in press in the *Philippine Journal of Science*, and Mr. Octubre's paper is ready for publication.

Cane

Our work on cane has been limited in accordance with our facilities for such work, yet we have had a constant succession of cane cultures since the College was founded. Up to this time the work

on cane has been concerned with methods of culture, fertilization, and a careful examination of the respective merits of the various local varieties. We have carried through quite extensive studies of the various methods of handling cane seed. We have also carried through an investigation as to the optimum time for the cutting of cane, through one of our advanced students, Mr. Mirasol. Just at this time we have on the way (-34-) a series of fertilizer tests. In all we have had under experimental investigation 21 strains of cane and have obtained yields running to 50 and 60 tons of cane to the hectare, without fertilization. This year we have determined the presence in the Islands of a serious rind disease related to the rind disease of Hawaii. We have also determined the presence in the Islands, heretofore unknown, of the Javan cane-borer, which is a serious pest wherever it occurs. To these and other serious insect and fungus troubles of the canes we are giving a good deal of attention.

On cane the college has published five papers.

Fertilizers and the Growth of Cane, by Clodoaldo Tempongko, in *Philippine Journal of Science.*

The Influence of Fertilizers on the Growth and Production of Sugar cane, by Silvestre Asunción, Philippine Agriculturist and Forester, *3* (1914) 69.

The Handling of Seed Cane, by Alfredo Adriano, Philippine Agriculturist and Forester, *3* (1914) 41.

Chemical Changes During the Ripening of Sugar Cane, by José Mirasol, Philippine Agriculturist and Forester, *4* (1915) 101.

Sugar Manufacture at the Calamba Sugar Estate, by Segundo Labayen, Philippine Agriculturist and Forester, *4* (1915) 92.

Maize

Our first work with corn on the College farm was concerned largely with methods of culture and systems of fertilization that should be feasible for the common Filipino farmer. It has been easy for our students to demonstrate that better preparation of the soil, more open planting, and more thorough subsequent cultivation would go far toward increasing the quantity and the quality of the corn crop. Students have also carried out various experiments to test the effect of leguminous cover crops upon the following crop of corn, and have tried out considerable series of fertilizer experiments, using materials that were available to the common Filipino farmer. In one of these cases it was found that a medium dressing of ordinary cattle manure doubled the yield over a nearby check plot, and gave per unit area a crop two to three times that ordinarily harvested by native farmers in this vicinity. We are now beginning the systematic seed selection of maize (-35-), combined with ear to row tests. We expect to carry this out on the very best plans that have been evolved in the most successful corn growing countries. In spite of all that has been said and written in connection with various corn campaigns in the Philippines, corn selection such as is now so successfully practiced in Iowa, Illinois, and other states of the Union has never yet been carried out here, and this work we now have under way. Our present corn work proceeds from 124 original cultures, and includes five new hybrid strains produced at the College. The action of some foreign corns introduced here for the first time has been most instructive and important; certain sweet corns (-36-) and certain fine foreign corns like Iowa Ideal give in the first generation only dwarf plants with very small, partially developed ears. Seed from these—which might well have been judged of no value—give in the second generation normal plants, of good yield and with great promise for the future.

Corn presents some highly interesting and important possibilities in connection with breeding. This is emphasized by the fact that the male and female flowers are widely separated on the plants. When left to themselves, a good many ears are fertilized by pollen from the same plant, and on the whole this is not conducive to the highest possible yields. The fact that pollen—the fertilizing material—can be carried for some 6 miles by wind opens a great field for investigating the possible effects of crossing of varieties that stand near to each other, and the practical results that may follow therefrom. One of our advanced students, Mr. Mendiola, has done a very great amount of work in the investigation of this matter. Some of his conclusions are of the highest practical value. For instance in one planting he detasseled all of the alternate rows, thus compelling a far greater percentage of plants to set ears through fertilization by other pollen than their own. The field in which this was done showed a gain of 18 percent over a field beside it that was not detasseled. He also planted fields in which the alternate rows represented different strains of corn, thus compelling wholesale hybridization. In one single case a field so managed showed a gain of 75 percent in yield over one of the parents. The resulting crop showed gains in the weight, length and diameter of the ear, number of kernels per row, and in the number of grains per ear.

Our publications on maize have been:

The Influence of K-P-N on the Growth and Production of Corn, by Toribio Vibar, Philippine Agriculturist and Forester, *1* (1911) 175.

The Growth of Maize on Cogon Soil, by Andres Navarro, Philippine Agriculturist and Forester, *2* (1912) 11.

Hybridization of Corn, by Nemesio Mendiola, Philippine Agriculturist and Forester, *3* (1914) 165.

Field Tests of Corn, by José Camus, Philippine Agriculturist and Forester, *3* (1915) 193.

A Study of Indian Corn, by J. C. Rundles, Philippine Agriculturist and Forester, *3* (1915) 228.

The thesis of Mr. Montellano, on the use of fertilizers on maize, is ready for publication, as are also those of Mr. Marquez on corn breeding and of Mr. Aldaba on corn analysis.

Sorghums and Forages

In all countries in which they are grown, sorghums rank among the most valuable forage crops. They have become especially valuable in the warmer parts of the United States where great effort has been made to introduce valuable varieties from all parts of the world. Our experiments with sorghums at the College have given us the most promising results. Certain varieties give enormous yield in both forage and grain. We had one variety this year which in a thick planting gave a dense growth to 15 feet in height. This variety after the first harvest gave a ratoon crop to 5 feet in height, furnishing a large amount of forage. Something of a third crop may come from the same roots. We have also found that there is a marked reaction among the various varieties to seasons, some thriving during the dry season while others do not. We have just obtained from the United States a very large series of the promising varieties recently handled by the United States Department of Agriculture, and we shall give these a careful test at this place. In all the College has had 91 varieties of sorghums under experimental investigation. Closely associated with the sorghums are the broom corns, a number of varieties of which have been grown at the College with exceptional success. The first cultures presented a considerable mixture of types but numerous selections were

made with the expectation of establishing purer strains. These cultures prove that good broom stock can readily be raised in these Islands in any quantity desired. We also grow representative cultures of all of the important tropical forage grasses. Some of these we have already developed to the state of field cultures with good success. Mr. Elayda is carrying on special work in this class of cultures (-37-) and is preparing an exhaustive report on the respective value of all of these different crops for the Philippines.

Coffee

We now have small but well organized mountain and lowland plantations of coffee at the College, propagated and planted by our students, which include some 56 strains of the most promising coffees of the world. We once prepared, at the request of the government authorities, a comprehensive plan that should result in thorough practical tests of all these coffees not only at the College of Agriculture, but at other points in these Islands, and that would have cost the government the very modest sum of 23,000 pesos for a period of 10 years, and which, if it had been carried into effect 3 years ago, would now be yielding results of the highest possible practical value. Even as it is, we now have the most important experimental planting of coffee (-38-) existing in these Islands, though it be a small one. This plantation, now one year old, will, within 2 or 3 years more, if properly cared for, be yielding data of the great practical importance and not only that, but it will be furnishing extensive seed stock, for use in plantations elsewhere.

It is probable that fair results are as likely to be obtained just at this time, and without exact knowledge on the subject, from the planting of seed taken from the finest, strongest, most productive and most highly disease-resistant trees of the native coffees that have long been acclimated, as will be likely to come from the use of foreign seed of *robusta* coffee, of the adaptability or possible success of which here, we know nothing. It is not wise under any conditions or circumstances to involve common farmers of small means in operations which are, to a large extent, experimental in nature. The planting of *robusta* coffee in the Philippine Islands, with our present knowledge, is distinctly this. It may possibly succeed in some cases and then again it may not, and failures, as usual, serve only to discredit all efforts of the government in this direction. The single attempt at the planting of this coffee made a number of years ago by the Bureau of Agriculture was a failure. *Robusta* coffee has not given anywhere results greatly superior to the finest varieties of Arabica. The principal plantations of *robusta* in Java lie between twelve hundred and three thousand feet altitude. We do not know that it would be anything of a success outside of these altitudes. It is an actual matter of fact that *Liberica* coffee, which likewise has never received any comprehensive and carefully controlled trial in the Philippine Islands, has, under modern methods of production and preparation in Java, been bringing a higher price on the markets of the world than Javan coffee. It is probable that Liberica could be successfully grown over an immense area of territory in the Philippine Islands. As a result of the very extensive planting, breeding, and testing of many strains of coffee in Java, Dr. Cramer expresses the opinion that *abeocuta* coffee is likely to prove to be the coffee of the future. *Abeocuta* coffee is very strong and vigorous and possesses an unusually high degree of immunity to

the coffee disease. The only attempt ever made in these Islands to try out *abeocuta*, is now in progress at the College of Agriculture.

Cacao

The College has recognized the importance of cacao as a possible crop in the Philippines. The people attempt to raise it everywhere but without success, due to the loss of very large percentages of the pods by disease. The country is admirably suited to the growing of cacao, and there is no reason why the industry should not be built up along sound lines. At the College we have spent a good deal of time investigating the diseases affecting cacao, and one of our thesis students, Mr. Ghofulpo, has done considerable preliminary work in testing the use of fungicides in the control of the diseases. These efforts have been attended with more or less success and will be continued along more comprehensive lines. We have gathered together selected seed of a number of the best local forms and these are now growing (-39-) at the College. It is highly important that strong selected strains be brought in from neighboring countries and grown here with the idea of determining which is strongest and best under our conditions, and then using such strains for general distribution among the people.

The remarkable results in the planting of cacao obtained by the English in the Gold Coast among the black people inhabiting that region resulted in an increase of export from 80 kilos in 1891, to about 40 million kilos in 1901. The fact that we had never had such an effective case of practical development among the Philippine people induced the Professor of Agronomy to make, through official channels, an offer to the Secretary of Public Instruction to propagate a minimum number of 25,000 cacao trees per year, and obtain the planting of these among the people of this immediate region, at very small expense. This work would have been possible by the use of students.

Rubber

There are numerous localities scattered through the Philippine Islands, especially the southern Islands, which are well adapted to the growing of Para rubber. There are other regions well adapted to the growing of other varieties of rubber. There is not a little public interest in this matter. In view of these facts we have considered it wise to allow advanced students to at least become acquainted with the different kinds of rubber and the methods of care and propagation. In connection with this, very small plantings of the different varieties of rubber have been made on the College grounds. Some of these rubbers have made a very good growth at this place and their development (-40-) will be watched with interest. A good deal of valuable information has already been gathered as to their growth and reaction to local conditions, through one of our thesis students, Mr. Sarmiento.

Tobacco

Active work in tobacco began at the College three years ago with plantings of a number of the very best cigar tobaccos of the world, including Vuelta abajo, Connecticut Havana, Texas Cuban, Sumatra and Connecticut Broad Leaf. We were told by prominent Manila tobacco men that it would be impossible to raise tobacco of any value at the College. However, we could not see any natural reason why this should be so, and the culture work in connection with it was absolutely essential in association with the instructional work. The results of the first

year showed that fine tobacco could be easily produced at this point. This induced us to undertake at once a large series of selections, and to lay out more or less comprehensive plans for experimental work on this important crop. Series of fertilizer tests (-41-) were also begun.

We had hoped to be able to introduce some of the finer foreign wrapper tobaccos, but our cultures of both Sumatra and Connecticut broad leaf were not successes. In view of the fact that these important strains of wrapper did not appear to be suited to our conditions, we immediately planted selected seed from the best strains of Cagayan tobacco obtainable by us, and started a series of hybridizations between the Connecticut broad leaf and Cagayan. This work was placed in the hands of one of our advanced students, Mr. Tirona. He obtained a series of hybrids which when planted gave in the first generation a large variety of plants, several of which when cured produced admirable wrapper. Some of these wrappers took a special prize at the Exposition. Further cultures of this Tirona Hybrid enabled us to give it a fair test and to cure a larger amount of the leaves. This year its leaf was submitted to the Germinal Company. They immediately proclaimed it a "descubrimiento" in Philippine tobacco work and valued it at ₱1.50 per kilo at a time when good Isabela was selling at ₱.60. We are continuing work in the selection (-42-) of this as well as of the other tobaccos and expect to have pure strains of it in culture after this year. In the meantime at the request of the Germinal Company we have given them a considerable amount of the common stock seed of this new hybrid for testing in the north.

During the present season we are trying this tobacco, as well as other fine tobaccos, both in the open fields and under cheese cloth, the latter work (-43-) being in the hands of Mr. Paguirigan, one of our advanced students. All of our tobacco work, from the planting of seed to the setting of the fields, the harvesting of the crop, and the curing of the leaf, has been done by students. Hired labor has never been used in connection with any feature of the work. During the first years, curing was accomplished under great difficulties and without the proper uniformity of results. This year a tobacco-curing house is being erected on the College grounds so that in future years, more extensive field cultures will be possible.

Root Crops

The root crops have since the beginning of the college received constant attention here, and altogether the experiments have been more extensive, and the results more ample, than have ever been obtained elsewhere in the tropics, or under any single office elsewhere, unless the sugar beet and potato be considered. This has been in part because this subject has admitted of profitable study on the small scale which was possible to the college, and in part because these root crops are at present of great importance in the Philippines, and ought to be of very much greater importance. There is no doubt that rice will remain the principal food of the Philippines, and it may be that other grains will continue to occupy the place of second importance. Neither is there any doubt that too exclusive attention to grains has resulted in famines and continues to be the cause of the danger of famines, and that the possibility of famine would be removed by adequate attention to the root crops. We have no doubt that when a government office undertakes a campaign in favor of diversified agriculture, with

the principal object of stimulating the production of other products which will take the place of rice when rice fails, the object can more easily, more cheaply and more satisfactorily be realized if the stimulus be given to root crops than if attention is devoted to maize. The same general factors, both pests and drought, which are responsible for the failure of rice, operate, sometimes with less force and sometimes with greater force, against success with maize. Root crops are comparatively immune to both of these dangers. To some extent maize competes with rice for the use of land, while the root crops, because of the greater production from the individual plant, can be grown satisfactorily on rough ground which is practically valueless for grains and is accordingly left waste in all parts of the Philippines. Our results have shown conclusively that, without greater expenditure of labor, it is possible to realize with various root crops greater returns from the unit of area of land than is over possible with maize; and, at present Philippine market prices, decidedly greater profits than are possible even with rice.

Our work with root crops has taken up four principal groups; the *gabis*, the yams, the *camote*, and *camoteng kahoy;* and has given minor attention to various other individual products.

With the *gabis*, and their relatives, we have made by far the most ample series of comparative experiments which has ever been undertaken in any place. In the preparation of his graduating thesis, Mr. Francisco Quisumbing made a trial of fifty known varieties, and of fifteen or twenty which were collected without names. Even before this, we had demonstrated on a small scale that, with the ample use of water and fertilizers, it was possible to produce with one of the yautias, a West Indian plant related to *gabi*, a crop of 120 metric tons to the hectare. No crop on earth has ever yield a crop of this size before. Mr. Quisumbing showed that a number of varieties of yautia exceeds the best of our native gabis in production, and that among our *gabis*, the varieties in most general cultivation are distinctly less productive than is one strain which was obtained from Mindoro. Local tests of the yautias as to their palatability resulted in the general conclusion that even those who are accustomed to eat *gabi* find the yautia equally palatable. In Porto Rico, where both yautia and *gabi* are old in cultivation, the yautia sells uniformly at the higher price. Mr. Quisumbing's work included chemical analyses to demonstrate the nutritive value of a large number of the varieties with which he worked. The more promising varieties have since been given tests on a field scale, demonstrating that Mr. Quisumbing's results can be realized commercially. We are continuing this (-44-) on a scale sufficient to provide material for distribution, and are constantly giving these plants away to any who apply for them. Work on a smaller scale has been carried on with these crops by the Department of Agriculture in Java, and on my visit last winter, I secured the thirteen varieties which were there regarded as most promising. These are now being tested here, with one variety from Japan and one additional native variety.

With the yams also, we have made the most extensive test of varieties, as industrial crops, of which there is any published record. This work was taken up by Mr. Mariano Raymundo with the use of every variety which the students of this college were able to collect from their various provinces, and was carried on by Mr. Raymundo for more than a year. Mr. Raymundo then left for the United States, and the cul-

tures were carried to a field scale (-45-) under the personal direction of Mr. Gerardo Ocfemia. Mr. Raymundo's work included a study of twenty distinct varieties of *ubi*, six of *tugui*, two of *ubag*, two of *mayatbang*, two of *nami*, one *limalima*, and one *kerime*. To this collection, we have since added four varieties from Java, two from Japan, one from Guam, and one from Hawaii. Trial on a small scale indicated a calculated yield from some varieties even greater than that already quoted for yautia, and a yield in excess of 50 tons per hectare from several varieties. These yields can of course not be expected to be fully realized on a field scale. It does appear, though, from field cultures, as well as from nursery cultures, that yields as high as a thousand pesos per hectare at current market prices can reasonably be expected. More than this, it has been demonstrated by the repeated verdict of our students who have tested these yams that some of them are delicious food. We are now ready to distribute some of the best of these yams in large quantity.

With camotes, again, we have made here the most extensive comparison of varieties of which there is any published record. In the preparation of his graduating thesis, Mr. Apolonio Muños made trial cultures and careful descriptions of twenty varieties, and prepared keys by which they may be identified. The following season, Mr. Gonzalo Merino made tests of fifteen additional varieties and carried his tests onto a field scale. We have since secured five more varieties, making a total of forty tested here. Some of these have been found practically valueless, and work with them has been discontinued. Others have been found valuable for particular uses. Even methods of cooking have been experimented with, and some are found to be excellent if cooked in one manner, and others cooked in other ways. Some thrive in wet weather, while others are particularly adapted to the dry season. As a result of this work, we are able to recommend the varieties best suited to any season and to any use, and to furnish material for the propagation of any variety which we recommend. We have given away more than a million cuttings, for a considerable part of which the only public credit has been received by the Bureau of Agriculture. About 600,000 cuttings are ready for distribution.

The *camoteng kahoy* is the most neglected promising crop of the Philippine Islands. It is the staple food, taking the place of rice, with the Samal Moros. It is perhaps a curious reminder of this fact, that in the extreme north of this Archipelago this plant is known as *camote moro*. Everywhere else in the Philippines, the plant is known and its productivity is recognized, but it is regarded as at best an emergency recourse in time of famine. The low value placed upon this plant, as a source of food, results entirely from the fact that its proper use is nowhere understood. Boiled, like a potato, it is indeed an exceedingly poor article of human diet; but eaten even in this way, there is a very great difference in varieties. One of the Samal varieties is produced in half the time of the variety widely scattered over the Philippines, and is distinctly sweet. When hungry, and in the field, I have been glad to eat this without any cooking at all. But the principal proper use of the *camoteng kahoy* is as a source of flour or starch. Java exports every year several million dollars worth of cassava flour and cassava starch, the product of *camoteng kahoy*, and produces this flour and starch from varieties

decidedly less productive than are two which we have here in cultivation. We have made at this college hundreds of attempts to isolate the most promising pure strains of *camoteng kahoy*, and are now carrying on field work (-46-) with four varieties whivh are particularly worthy of cultivation, as demonstrated by our own previous tests. We have also several Javanese varieties, which we are propagating on a small scale. We can at any time furnish any desired amount of these plants for propagation.

On a smaller scale, we have worked with various root products. One of our students has been engaged for a year in a study of the possibility of the local acclimatization of the common potato (-47-). This study has involved the use of various varieties, and has been carried on at different altitudes on Mt. Maquiling, as well as on the college farm. As an outgrowth of the college work, several of our students and neighbors are growing potatoes around their houses.

With *sincamas*, we have made field tests with the expectation that this would prove a particularly desirable hog feed, but the expectation was not realized. Our hogs refused to eat raw *sincamas* so long as they could get other food. *Calamismis* is in scattered cultivation in the Philippines for the sake of the fruit. In Burma and Indo-China, it is raised as a root crop and the roots are sold at a higher price than those of any other plant. Our experiments have shown that with one of the two distinct local varieties, it is possible to produce roots which, though small, are very palatable, and yield a very respectable total crop per hectare. With ginger, we have made trial tests of the Jamaica variety, which is very much richer in oil than is the ginger native here. With arrow root and Otaheite arrow root (*yabyaban*), we have made only nursery trials. The *yabyaban* will live and produce a crop here, but the soil is too heavy for its commercial production. Where sandy soils are available, which is only locally the case in the Philippines, this crop should be the most profitable which can be grown.

Work so far published from this college on root crops is as follows:

Maniok Varieties, by E. B. Copeland, Philippine Agriculturist and Forester, *1* (1911) 22.

Root Crops, by E. B. Copeland, Philippine Agriculturist and Forester, *1*, (1911) 23.

Chemical Analyses of Cassava (Camoteng Cahoy), by José Camus, Philippine Agriculturist and Forester, *3* (1914) 75.

The Chemical Composition of Philippine Sweet Potatoes, by Segundo Labayen, Philippine Agriculturist and Forester, *3* (1914) 79.

The Philippine Root Producing Aroids, by Francisco Quisumbing, Philippine Agriculturist and Forester, *3* (1914) 85.

Identification and Tests of Varieties of Sweet Potato, by Apolonio Muñoz, Philippine Agriculturist and Forester, *3* (1914) 127.

Field Tests of Sweet Potatoes, by Gonzalo Merino, Philippine Agriculturist and Forester, *3* (1914) 146.

Report on a Collection of Living Dioscoreas (Yams) from the Philippines, by I. H. Burkill, Director of Botanic Garden, Singapore, Philippine Agriculturist and Forester, *3* (1915) 205. Mr. Burkill has since published more completely on the same subject in the *Bulletin of the Singapore Botanic Garden.*

Additional detailed reports on various roots crops are included in the published reports of our Department of Agronomy.

Bananas and Other Fruits

Since bananas form a standard article of diet among the Filipino people and since hundreds of distinct varieties exist in Malayan and other countries, it has seemed to be desirable to test all of these varieties, under modern methods of culture, as to their respective value for different food purposes. A serious problem connected with bana-

nas presented itself to us at the outset —that of the identity of the varieties, (-48-) there being a great confusion of names, the same variety carrying different names in different localities and different varieties frequently appearing under the same name. One of our advanced students, Mr. Teodoro, took up this matter and has given it very careful study with the result that he has already completed a most important work on the identity of some 20 varieties. This study is now being published in the *Philippine Journal of Science*. A large collection of varieties gathered by Mr. Barrett of the Bureau of Agriculture at Singalong, has now been transferred to the College of Agriculture with the result that our plantation now includes 460 varieties gathered from all parts of the world. We have also had contributions to these cultures from the United States Department of Agriculture.

One of the most important items in tropical horticulture is the growing of fruits. This is true in all tropical countries and especially in the Philippines where fruits are extensively used as a common article of diet by the people and where the native supply does not satisfy the demand and where fruits are imported in large quantities. Fruit raising can easily be improved by seed and bud selection and by better methods of culture. Work along these lines is constantly being carried out by the students at the College and our cultures of all the standard fruits are constantly growing in value.

Of the various classes of citrus fruits (-49-) we have had 112 strains under investigation, and our plantings in this important group promise to rapidly become of great economic and educational value. Of mangoes (-50-) we have worked with 33 distinct strains. Of the annonaceous fruits (-50-) including the *anonas*, *atis*, and *guanabano*, fruits of great importance everywhere in the Philippine Islands, we have been engaged with 43 strains. Pineapples (-51-) are raised everywhere in the Philippines and are commonly of poor quality and do not supply the local demands, since considerable quantities are imported. We have 17 strains in culture on the College farm. An important series of investigations have been carried out therewith in connection with methods of handling seed, methods of culture and different systems of fertilization, by one of our thesis students, Mr. Capistrano. The fruits falling in the genius *Nephelium* (-52-) and including the litchi, the rambutan, and related fruits, are already of importance in the Islands and their culture can easily be greatly improved and extended. One of our advanced students has been carrying on some special study of the *lansones* (-53-) with the result that he has located some very exceptional strains, including some seedless forms of high value, and these will be propagated at the College. Of the fruits of lesser value, including a considerable number of bush and small tree fruits we now have in culture above 50 strains. Of these the guavas are of special importance and might be the means of establishing here a very considerable industry in the manufacture of guava paste and guava jelly, such as exists in the Island of Cuba. Guavas grow wild everywhere, in the Philippine Islands, but are of such poor quality that they are scarcely usable for any purpose except hog food. Of the guavas we possess 7 improved strains.

The College publications on fruit are:

The Pomelo, by C. F. Baker, Philippine Agriculturist and Forester, *2* (1912) 62.

Improvement of the Papaya, by C. F. Baker, Philippine Agriculturist and Forester, *3* (1914) 15.

The Banana Fruit, by José Dacanay, Philippine Agriculturist and Forester, *3* (1914) 81.

Some Experiments in Pineapple Planting, by S. M. Capistrano, Philippine Agriculturist and Forester, *4* (1915) 45.

A study of methods of preserving fruit (-53-) is nearing completion.

Legumes

From the beginning of its existence the College has recognized the very great importance of legumes in Philippine Agriculture, not only because of their high value as soil renovators and green manures, but on account of their high food value for both man and the domestic animals. Consequently legumes have entered very largely into the cultures of the College farm. We have had under investigation 44 varieties of cowpeas and 10 of soy beans, 437 varieties of garden beans and peas, about 10 strains of peanuts, 6 strains of mungos, and half a dozen legumes useful as green manures alone. We have been making steady advances in the improvement of all of these by selection, especially in the cases of cowpeas, soy beans, mungos and peanuts. Our separate selections in these crops have run into the thousands, and the work of separately culturing these, and testing their respective merits, is now in active progress, in the hands of students. In the cowpeas (-54-) we have made numbers of selections of parent individuals which have shown themselves to be almost entirely free from the disease afflicting this plant during the wet season. These will be cultured during the coming wet season, with great interest. In the soy beans (-55-) supposed by some not to be possible of successful culturing in these Islands, we have made the interesting discovery that out of many varieties, certain ones have proven themselves especially adapted to our wet season, and certain others are especially adapted to our dry season. These are likely to prove of great economic importance for the reason that there is a very considerable importation of soy beans and soy bean products into these Islands. Peanuts are of great importance anywhere in the Philippines since they are used for a variety of purposes by the Filipino people and the home product has not yet been able to supply the demand, large amounts being annually imported. We have brought here for thorough study, and have grown with considerable success (-56-), 10 of the very best varieties in the world, and work on these is still in progress at the College. Considerable quantities of seeds of these improved strains have been distributed through the students.

In connection with the work in Animal Industry, we have been using cowpeas, soy beans, and peanuts as pasture crops for hogs, clearly demonstrating that these crops can be used by Filipino farmers to very good advantage in the intensive production of pork on small areas of land. Our preliminary investigations in connection with garden beans and peas have been in the nature of acclimatization work. Practically all of the current varieties of these plants in the seed markets of the world were obtained in small quantities, and planted here under careful control.

One of the great virtues of work of this character is comprehensiveness. This is to say that if acclimating is to be attempted at all it should involve all of the varieties of the plant under investigation that can be obtained throughout the world, for the reason that if only a portion were obtained it might easily occur that the very variety that would have proven a great success and added an important agricultural asset to the Islands might have been

one of these which we failed to get. With this aspect of the matter in view our work of this character along all lines has been brought as near to perfect comprehensiveness as our facilities allowed. In our present work, taking the legumes as a whole, we have more than one thousand selected strains in process of testing, improvement and multiplication.

The attention of our students is constantly drawn to the great value of legumes as green manure. It is possible to very completely renovate exhausted lands by the wise and thorough use of green manures. We are working (-57-) with a considerable number of legumes that are especially adapted to this purpose. This includes a number of varieties of velvet beans and 2 or 3 promising varieties of *Phaseolus*. It has previously been shown in Florida that a crop of velvet beans, plowed under, might easily furnish as much as 100 pounds of nitrogen per acre in the vines and 9.7 pounds in the roots. At the current price of nitrogen in commercial forms in Manila, this would be a matter distinctly to be taken under consideration in any rotation system.

On legumes, the College has published:

An Economic Study of Beans, by E. M. Ledyard, Philippine Agriculturist and Forester, *2* (1912) 66.

Papers are finished, and awaiting publication, on peas by Mr. Dacanay, on cowpeas by Mr. Constantino, on peanuts by Mr. Consunji, on color variation in seed crops of cultivated legumes, by Mr. Galang, and on growth of legumes as influenced by lime, by A. Laparan.

Sesamum

The plant called *liñga* by the Filipino furnishes in India one of the most important oil crops of the Orient. It is also of high nutritive value for direct consumption. It is commonly eaten as an article of luxury by the Filipino people and the supply rarely equals the demand. It could and should be more extensively grown. Immense quantities are imported into Europe each year from the Orient, and it might very well be raised here for export if economical methods of culture can be devised for it, and if selected strains of the highest yielding capacity are propagated, and the seed distributed among the people. Our work at the College in this direction has been very active and has been accompanied with very successful results. We started out with stock cultures of several strains from this country and from abroad and discovered immediately that they were composed of great mixtures of types of varying vitality and productiveness. The work in selection was undertaken first by one of our thesis students, Mr. Zulaybar, who obtained very considerable results in his first year of work, an account of which has already been published. The strains separated by this student, and also others that have been separated more recently are now in culture (-58-) and some of them are giving very remarkable results. As rapidly as possible the most highly desirable of these strains will be carried into field cultures, so that large quantities of valuable seed will be available for distribution.

Tropical Gardening

Tropical gardening other than fruit culture is in a very undeveloped state in all hot countries. There is an enormous amount of acclimatization work greatly needed, and seed selection will play a large and important part in its proper development. At the College of Agriculture we have gone into this work extensively and given all students abundant training therein. As a result of the more or less comprehensive work

done by each student under competent direction, the College is gathering a large amount of practical working data of the highest possible value. The work on garden beans and peas has already been mentioned. Our work in a number of the other groups is no less comprehensive. We have carefully tested here in all seasons, a great variety of tomatoes, eggplants, lettuces, radishes, squashes, etc., including in our operations nearly all of the standard varieties of the world. One of our thesis students, Mr. Uichanco, has completed a very valuable study of the tomatoes showing that it is possible to considerably widen the tomato seasons in both directions, and thus avoid a large amount of loss that occurs through a glutting of the market in one short harvest period. Another thesis student is now engaged in similar work with the cruciferous vegetables (-59-), and another with the cucurbitaceous vegetables (-60-).

There is a considerable series of medicinal and pharmaceutical plants of great value which might easily be cultivated in the Philippine Islands just as they are being cultivated in other warm countries. We are now establishing small trial plantings of a number of these.

Students are given opportunities for good training in decorative gardening, in the propagating and handling of ornamental plants, and in setting these out and caring for them.

Animal Industry

In spite of the poor condition of this Department in matters of equipment, general instruction, covering all of the important types of domestic animals, principles of feeding, and meat and dairy and egg production, has been regularly given to all of the students of the College entering these courses. In connection with this work classes of students have been taken to many points away from the College in order to make an intimate examination of pony, carabao, and vaca stock, hog breeding, and poultry and dairy work, as these exist in the Islands at this time.

Even with a limited amount of stock in poultry, the College has carried through a number of very important pieces of special investigation in connection therewith. One of our advanced students, Mr. Allarey, made a study of the native chicken as it exists in the Islands at present. Another advanced student, Mr. Velez, has presented a comprehensive piece of work comparing the native chicken with half-breeds produced from various lines of improved blood. Still more important tests in connection with a comparison of various types of mestizo poultry under a variety of systems of feeding (-61-) are now in progress in the hands of another of our advanced students, Mr. Cruz.

During the early days of the College a comprehensive plan was formulated by the head of the department, Mr. Durham, for a thorough investigation of hog-raising in the Philippines, more particularly from the view-point of the small farmer. This was essential to the proper instruction of students and promised to have very real value of wide application in connection with the development of Philippine Agriculture. It was necessary to determine exactly the most economical way in which a pound of good pork can be produced on the most limited area of land. The plan involved trials with a number of breeds and native grades, using different systems of feeding and pasturage. The work along these lines has been in progress at the College for about two years and the results so far obtained have been illuminating and

valuable. These results show the exact amount of pork that can be produced from a pound of corn and also from varying amounts of corn in connection with numerous types of pasturage. It shows conclusively that in the hands of small farmers, and with only the facilities that are readily available to the small farmers, there are very great possibilities in connection with pork production in the Philippines. Our results here include the interesting fact that per unit area of land it is readily possible for the Filipino farmer to secure a far better return than he is at present able to secure in this region from either rice or cane. This work is now being actively continued (-62-) though without a sufficient equipment of stock, by one of our advanced students, Mr. Cui.

The College publications regarding animal industry have been:

Advice on Horse Breeding in the Philippines, by S. B. Durham, PHILIPPINE AGRICULTURIST AND FORESTER, *1* (1911) 13.

Live-Stock Farming and Soils, by M. M. Cruz, PHILIPPINE AGRICULTURIST AND FORESTER, *1* (1911) 54.

Scale of Points for Philippine Pony, by S. B. Durham, PHILIPPINE AGRICULTURIST AND FORESTER, *1* (1911) 138.

The Philippine Chicken, by Vicente Allarey, PHILIPPINE AGRICULTURIST AND FORESTER, *2* (1912) 49.

The Duck and Egg Business of Pateros, by M. B. Raymundo, PHILIPPINE AGRICULTURIST AND FORESTER, *2* (1912) 56.

Study of Philippine Carabao, by Gaudencio Evaristo, PHILIPPINE AGRICULTURIST AND FORESTER, *1* (1915) 123.

Mr. Durham's report on hog-feeding is in press, and Mr. Velez' thesis on poultry is ready to print.

PERSONNEL

As to personnel, statements of the force already here have been given in the discussion of the work of the several departments, and in the same connection some idea has been given of our additional needs. The college should give organized instruction, in addition to the instruction already now given in the consideration of individual crops, on the subjects of farm accounting, and agricultural economics. It should also conduct investigations on economic, as distinguished from purely agronomic, problems. This work demands the service of a man well-trained for the purpose and can not be satisfactorily performed by a man who is merely a good teacher of other subjects.

There is a crying need for the work of an energetic and practical agricultural entomologist. Mr. Banks is doing all that can be demanded of him; if he does well the work which he is now undertaking, it is all that can be expected. But the pests of Philippine crops are being neglected, with consequent frightful loss which might be largely prevented.

In the field of Engineering and Physics, we need either a physics teacher so that Mr. Cuzner can give his entire time to engineering, or a practical engineer who can take charge of construction and repairs, and leave Mr. Cuzner his entire time for instruction.

In Agronomy, the services of a number of aditional men are needed, but for the most part men with the necessary practical experience and familiarity with our local problems do not exist. In the long run, Filipinos will of course be trained for all of these positions. But the task of giving adequate training in all the fields which demand attention is far too big for our present force. Rice, because it is the foremost Philippine crop, should receive first and foremost attention. Horticulture is another field which urgently demands intensive study. The department of Agronomy needs also a thoroughly competent record clerk. Our experimental work loses a large part of its value if the re-

cords are not absolutely complete and reliable. I regret to have to say that they are not now in satisfactory condition, and that our present force does not make it possible to keep them in satisfactory shape.

Animal husbandry in the Philippines, and government work in this field, have never been even decently organized, and I do not think that there is any man in the Philippine Islands capable of organizing it. The regents of the University have recognized this condition and authorized the employment of a professor of animal husbandry, but it has been impossible to fill the place. Animal husbandry, when it is well organized, will demand the service of at least six thoroughly trained specialists. For the most of these positions, Filipinos can be trained, but without one or two thoroughly first class men to plan and carry on this work, the training of the other men from our student body is making no progress whatever. The record of our work in agronomy, in which a number of Filipinos are already well advanced in their training, shows exactly what ought to be done in animal husbandry.

Except in Animal Husbandry, I am not in favor of adding to the staff of this college a single man who has not the double qualifications of demonstrated ability of a high order and long experience in the tropics. The employment of men without both of these qualifications is in general both unnecessary and exceedingly foolish. The employment of men without either of these qualifications is perfectly absurd. When the right kind of men can be obtained, they ought to be obtained AND KEPT. When they can not be obtained, we must do what we can to train our students to meet the demand. In the long run, our students will of course be trained to fill all, or practically all, of our places. In the meantime, we are in particular need of men of first class ability, because these men must not only be able to apply first class ability to the solution of our practical problems, but must also have the additional duty of training a considerable number of students for future work of the same kind; by no means every good investigator is a good teacher. The exception to be made to the requirement of tropical experience, in the case of animal husbandry, is for the reason that there are no well-trained tropical animal husbandmen.

LAND AND BUILDINGS

As regards buildings, the college has never had room to do its work comfortably or well, except for about one year, after its first concrete buildings were completed. There is not a single department which is not too crowded for the highest efficiency. This crowding is particularly detrimental to practical work, because the care which is necessary for reliable results demands room enough to preclude the possibility of confusion. We have harvested tons of root crops and grain from which we were unable to make selections as carefully as the work should have been done, simply because we have not sufficient space in which to spread the materials out for comparison. The condition of our agronomy classes reminds me of sardines, except that the sardine, although somewhat crowded, is not required to work. This detriment to efficiency makes itself acutely felt from the day the student matriculates here, for the fundamental subject of botany has to be taught during the first year in a badly crowded room, which was never intended, and can not be decently equipped, for a botanical laboratory. Our work in chemistry would be much better done if its students had twice the pres-

ent desk space, and there is no place in the chemistry laboratory which can be devoted to the analytical work constantly called for by the Department of Agronomy. In Entomology, our equipment has less space than it had in the Bureau of Science. But here, the equipment has to share what space it has with one hundred students. Of all our departments, agronomy, which ought to be best taken care of, is the most ruinously congested. Animal husbandry alone has adequate room; its room is more than sufficient, because there is no faculty and almost no work being done; accordingly, its space is largely used for agronomy.

Equipment

For equipment in botany, chemistry, entomology, and physics, we have usually been able to secure such funds as would enable us to keep not more than one year behind our urgent needs. In agronomy and engineering, we have not been able to do nearly this well. In animal husbandry, we have hardly done anything. Our livestock is at present as follows:

20 Bullocks	₱2,429.60
90 Poultry	159.56
7 Goats	14.00
16 Hogs	285.00

We have never had a horse, nor a carabao, nor any beef or dairy cattle. Neither have we had any draft cattle better than very ordinary examples of the native stock, except while the Bureau of Agriculture loaned us an imported herd of Nellore cattle long enough for us to get the beasts into decent condition. Leaving any kind of experiments in animal husbandry out of account, our stock of work animals is utterly insufficient for the cultivation of the land we have. The Negrito farm school in Zambales, with five hectares of tillable land, has been provided with more work animals than has this college. For intensive work such as ours on the area we are cultivating, we should have fifty rather than twenty work cattle, in order to give them as much rest as is necessary to maintain them in good condition.

With regard to equipment for farm work, we have five carts, seven cultivators, seven harrows, and seventeen plows. These are sufficient for our farm-work as it is being done, and would be more than sufficient if it were not that we need to have a variety in order to acquaint our students with the different types. For this purpose, the collection should be more ample than it is. We are almost wholly without special apparatus for the cultivation, harvesting, and subsequent treatment of particular crops and are entirely without traction machinery. Traction machinery is needed in the Philippines. It is especially needed, because of the dearth of draft animals, but would be needed in many places for the sake of greater efficiency, if our supply of draft animals were ample. Farmers here and there over the Islands are continually importing machinery, with the most frequent result that they do not know how to handle it, and finally abandon the attempt. If farm machinery is to be successfully used, there must be men who know how to use it. It should be the business of this college to train men to use farm machinery. But, without such machinery, how can we do this?

It is not fair to the students, and not fair to the Filipino people at large, that the boys who go through this college should not have seen a threshing machine, a steam plow, or a cable plow, any kind of an harvester or a rice huller; it is not reasonable that, when we are attempting to teach them the business of producing and harvesting coffee and cacao, we should be unable to give them any practice with the machinery absolutely necessary for such business.